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Papers on the present and future use of technology in education is presented. Harry F. Silberman, in "Evaluative Criteria for Automated Teaching Programs," presents comments, criteria, and tables on automated teaching programs. He describes experiments on the effectiveness of branching and fixed sequence programs, on a followup experiment using a digital computer as a control unit to permit a more complex form of branching, on interactions between measurements of individual differences and method variables, and on different methods of repeating items for review purposes.

Leon Hibbs, in "Instructional Television and MPATI" explains that Midwest Program Airborne Television Instruction (MPATI) is a regional experiment to offer improved quality of instruction at low cost to schools which are deficient in facilities and instructional competence. Some of the technical aims are to test the practicality of transmitting a television signal from a highflying aircraft and to determine if it is possible to double the number of television channels.

Murray Tondow, in "Educational Data Processing," comments on aspects of data processing that primarily relate to the learning process as differentiated from the structure and form of education.

Launor F. Carter, in "Automation and Education," discusses the general aspects of introducing automation techniques into the educational system.

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SYMPOSIUM PROCEEDINGS

T E C H N O L O G Y I N E D U C A T I O N

Denver, Colorado
December, 1961

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
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PREFACE

Section "Q" of the American Association for the Advancement of Science (AAAS), conducted a synopsis on technology in education at the Denver meeting, December 26-31, 1961.

Those who were present asked if it would not be possible to have a digest of the papers presented available for distribution. Through the courtesy of Mr. Murray Tondow, Editor, Educational Data Processing Newsletter, Chicago 25, Illinois, these papers are now available in this monograph.

Improvements in education through technology are as important to advancement as are self-starters, automatic washing machines, computers and space ships.

Why are educators so slow to take up and use the new applications? It takes money, know-how, insight, courage and desire to change. The first two are in short supply in education. The latter three are present but dormant at the present time.

In education we have been taught to believe in the enduring truths. But we confuse the truth with a fact, a way of working, a method. Sacred cows, not sacred truths, take over, and so we cling to 40-minute class periods, five times a week, 20 X 30 cubicles, and the 180-day school year.

Rather than detracting from the role of the teacher, technology can take much of the drudgery from teaching and release the teacher to do what only a human mind and heart can do - lead children and youth to use their great capacities to the fullest.

There is hardly a thing in education which will not be helped by technology: teaching, guidance, planning, administering, diagnosing, researching.

These papers give a glimpse of how some people are working, and what we may expect in the future.

William H. Bristow
Chairman, Section "Q" - AAAS
Assistant Superintendent
New York City Schools

PREFACE FOR SYMPOSIUM

Throughout science and technology we are hearing more and more regarding the "systems approach." In system development we are concerned that all parts of a system be developed coherently and integrated together to form a smoothly operating system. It was with this thought that we arranged this symposium on "Technology in Education."

There has been a tendency in educational research to be concerned with one limited aspect of the total education process, for instance, primary reading training or counseling of high school seniors or some other rather easily defined entity. In this symposium, however, we wished to consider the total problem of the ways in which modern technology can be applied throughout the educational system. We have not touched upon all the different technological aspects that might be applied to education; for instance, we have not dealt with problems of transportation or the mechanical aspects of the school plant or many other technical problems which are very important. Rather, in our symposium we dealt with technology as it impinged on instruction, counseling and the record-keeping aspects of school operations. Some of these areas are dealt with in greater detail than others because of the particular interest and competence of the individuals giving the papers. In the symposium we tried to deal with three ways in which modern technology is currently being used to influence educational developments. First, there is a very interesting and provocative discussion of the new educational television demonstration-experiments being conducted by the Midwest Program of Airborne Television Instruction. There are many other possible examples of the use of television and audio-visual aids in the educational system but this particular program is very new and causing a great deal of interest in educational circles. Second, there is a discussion on educational data processing. The magnitude of the problems of educational data processing is often overlooked. The number of clerical manhours devoted to this activity, not only by clerks but by teachers and administrators, is staggering. With the introduction of modern electronic data processing equipment there have been great advances in the efficiency and completeness with which record keeping activities can be performed in the school system. Finally, there are several papers in the area often known as automated education. One of the papers summarizes the research result for several of the variables affecting the efficiency of automated education and the other paper describes in some detail the current status of automated education and particularly describes the development of a system laboratory for the integrated study of the application of technology to education.

It is hoped that this series of papers will give the reader a current picture of the way in which technology is being applied to education as well as a glimpse into the future so that he can prepare himself for the coming changes in our educational practices.

Launor F. Carter
Symposium Chairman

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EVALUATIVE CRITERIA FOR AUTOMATED TEACHING PROGRAMS

By

Harry F. Silberman

System Development Corporation

This paper is concerned with some comments on evaluative criteria for automated teaching programs. Four experiments conducted at SDC will be described, to serve as a base for these comments.

In the first study (Experiment One), John Coulson and I attempted to evaluate the effectiveness of branching and fixed sequence programs. Using manual equipment, we compared a fixed sequence procedure with a branching procedure in which some items were skipped by Ss who made no errors. The findings showed that subjects with this very limited branching learned as well as those taught without branching, and learned in a shorter time.

STUDY #1 (Branching)

		Score		Time	
	N	M	SD	M	SD
Branching	40	13.2	4.3	43.8	10.0
No Branching	40	13.8	3.6	55.0	10.6

t (time No br - Br) $p < .01$

In a follow-up study (Experiment Two), a digital computer was used as a control unit. The computer permitted a more complex form of branching than was possible with manual equipment. When performance on basic material indicated that a subject had not learned, that subject was branched to remedial items. Some items were also included which asked the subject to evaluate how well he thought he was doing. If he indicated that he was doing well, he would be skipped ahead, while if he indicated that he was having difficulty, he would be given remedial work.

Two groups of Ss were used, a branching group and a fixed-sequence group. Ss in the branching group received a variable sequence depending on their performance while all members of the fixed-sequence group saw the same set of items. Analysis of posttest scores yielded a significant difference in favor of the branching group. Time taken in training also suggested a savings for the branching condition.

STUDY #2 (Branching)

		Branching	No Branching
Apt.	M	112.5	113.8
	SD	12.9	15.9
Score	M	74.3	65.4
	SD	10.7	14.9
Time	M	116.2	129.5
	SD	20.7	26.8
Items	M	213.5	233.
	SD	19.4	--

t (score Br - No br) $p < .01$

The third study in this series was conducted by John Cogswell and Ralph Melaragno of our staff. This study explored interactions between measurements of individual differences and method variables. Comparisons were made between students showing high test anxiety and low test anxiety on two different forms of a geometry program and with two different sets of instructions. One program contained extensive explanation and was quite easy. The other form of the program had many of the explanatory items deleted and was a more difficult program. One set of instructions was designed to be anxiety provoking while the other set of instructions was designed to be anxiety reducing. No significant differences were obtained between the high- and low-anxiety groups on either the easy or difficult program or with the anxiety-provoking or anxiety-reducing instructions.

STUDY #3 (Geometry)

		Easy Form		Difficult Form	
		Provoking Instructions	Reducing Instructions	Provoking Instructions	Reducing Instructions
High Anxiety	M	18.14	20.00	21.14	21.71
	SD	5.24	6.61	5.46	4.40
Low Anxiety	M	24.43	22.57	20.57	20.43
	SD	3.37	7.84	2.26	4.61

N=56

In the fourth study, John Coulson and I compared several different methods of repeating items for review purposes. Five groups were used. One group of students received a programed sequence of four geometry theorems with no repetition. In a second group each item in the program was repeated immediately. A third group received all of the items in a theorem and then the theorem was repeated before going to the next theorem. A fourth group received the entire program before the program was repeated. A fifth group received a condition in which the delay, between an item and its repetition, was increased as the learner progressed through the program. For example, in the first theorem, each item was repeated immediately. In the second theorem all the items were completed before the second theorem was repeated. In the remaining two theorems, all the items were completed before both theorems were repeated.

No significant differences were obtained among the five conditions on an immediate posttest and on a retention test.

STUDY #4 (Geometry)

	No Repetition	Each Item Repeated	Each Theorem Repeated	Entire Program Repeated	Items, Theorem Last Two Theorems Repeated
Score M	15.4	19.2	12.8	19.1	17.5
SD	7.4	7.3	6.7	8.2	8.4
Apt	114.9	114.5	109.7	117.2	111.9

N=85

In reviewing the results of these four studies, one can't help wondering why they turned out as they did. The variables in the two geometry studies seem more potent than the branching variable, yet these two studies yielded no significant differences. Assuming that the materials were carefully prepared and the experiments administered so as not to introduce extraneous variables, two explanations of the null findings are possible.

1. The independent variables may, in fact, have no real effect.

2. They may have a real effect but the treatment conditions that were used may not have been strong enough to be detectable within the sensitivity range of the criterion instrument.

The second possibility can be avoided by increasing the intensity of the treatments or the contrast between the treatments. Assuming that the treatments were adequate, then the criterion must not have been sufficiently sensitive. The criterion tests for these studies were indeed quite different. Most of the items on the two geometry studies were of the application type while the test items for the first two studies were more similar to the program frames.

Generally when an investigator refuses to accept null findings, he is suspicious of the adequacy of the treatment conditions rather than of the criterion instrument. Perhaps the branching variable was no more effective in producing the hypothesized result than the variables in the geometry studies. The criterion instrument for the two geometry studies may simply have been inappropriate. The characteristics of the criterion may have determined the conclusions in these studies.

An example in which the choice of criterion measure determined the conclusions is provided in a study by Gagne & Brown in a recent article in

the Journal of Experimental Psychology[1] on some factors in the programing of conceptual learning. They compared a guidance-discovery method, a discovery method, and a rule-and-example method, using as one criterion, the time required to solve four transfer problems. They found guidance-discovery most effective (16.7 minutes), followed by discovery (19.8 minutes), with rule and example least effective (27.4 minutes). If one adds the reported learning times to the times required to solve the transfer problems, however, and uses the total time as a criterion, this order is changed with the discovery method most effective (48.1 minutes) followed by the rule-and-example method (71.6 minutes) with the guidance-discovery method trailing this time (73.2 minutes).

Gagne and Brown Jl. Exp. Psychol. Dec. 1961, 62, 313-321

	Guidance Discovery	Discovery	Rule & Example
Xfer Problem Time	16.7	19.8	27.4
Total Time	73.2	48.1	71.6

Weitz[2] has also provided examples in which choice of criteria determine the conclusions of studies. The difficulty of the criterion, the extent of similarity with the training materials, the decision of when to administer the criterion instrument, the choice of performance measure, each determines in some way the results of the study. From the foregoing observations, one could surmise that perhaps one of the more important issues in current research on programing variables is the problem of choosing evaluative criteria. In this light it may be helpful to consider some of the problems concerning the criterion instrument.

A variety of criteria are reported in program evaluation studies. Internal measures such as percentage of errors have been quite popular. In other instances, immediate posttests consisting of selected items or criterion frames drawn directly from the program have been used.

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[1]Gagne, R. M., & Brown, L. T. Some factors in the programing of conceptual learning J Exp. Psychol., 1961, 62, 313-321.

[2]Weitz, J. "Criteria for Criteria" Amer. Psychologist, Vol. 16, No. 5, May, 1961, 228-231.

If the criterion frames in the program comprise the universe of behaviors which the program is intended to establish (i.e., if the criterion frames are identical with, and define, the educational objectives involved), then criterion frames may be sufficient as a direct measurement of mastery and can be readministered as the posttest. If, on the other hand, the criterion frames constitute only a sample of the behavior, which is intended to be learned by the student receiving the program, then performance on the criterion frames may give a distorted view of the student's learning and the amount of transferable learning produced by the program. That is, the student may have been coached in the program to memorize a sample of verbal stereotypes which may not generalize to an independent sample of test items. In such an instance, performance on the criterion frames would give an inflated picture of what the program accomplishes and would exaggerate the extent to which the student understands and is able to apply what the program is intended to teach.

If the program and the criterion test have been constructed separately, with a common list of behavioral objectives as a guide, the test items and the program criterion frames can be viewed as independent samples from a large pool of possible items defined by the stated objectives. The quality of such a test may be assessed only partially by conventional methods of estimating validity and reliability. Not only must the test items be relevant to, and representative of, the stated behavioral objectives, but the relationship between the test items and the criterion frames is equally important.

Crutchfield and Covington[3] have noted that the test items can be extremely close counterparts of the program frames--not only in terms of the item content, but also with respect to the manner of presentation of the item and the type of behavior called for. At the other extreme, test items can be selected widely from the total universe of topical content, behavior, and item types, varying from the criterion frames in content as well as in manner of presentation and types of response called for. These two extremes suggest a continuum along which the test performances can vary in degree from the required performances on the program frames.

Since the purpose of a program evaluation test is to measure the behavior that should have been produced in all of the students receiving the program, the items may be very easy. Such items do not discriminate among students and therefore result in low item discrimination indices. Hence, traditional item analysis data may not be particularly useful for program evaluation tests. Effective programs, yielding a very limited spread of scores on a posttest, attenuate any coefficients which are a function of variance among the test scores. Test-retest correlations, item-test correlations, and test-criterion correlations will all be reduced by a restricted range of posttest scores. The validity of a test, therefore, must be judged in terms of relevance of content and objectives, as well as statistical indices.

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[3] Crutchfield, R., and Covington, M. Personal Communication, December 1961.

If test items sample the essential subject matter that the student has learned from the program, and if items are not eliminated on the basis of item-test discrimination, correlations between success or failure on each item and the criterion score are zero if everyone answers each item correctly. Such a test may not discriminate well among students who have received the program but may still discriminate between students who have received the program and those who have not. Hammock[4] has suggested that test items be selected on the basis of their ability to discriminate between students who have and have not received the training rather than among students all of whom have received training. Gilpin[5] proposed that programs, with the same objectives, that produce perfect criterion performance on such a test may be compared on the basis of their efficiency as measured by the time required to complete the program. In most cases, however, all students will not receive a perfect test score.

Perhaps what is most needed to improve research on program variables is a standard method for expressing learning efficiency in terms of both test performance and cost factors. Such an index should not be based on unrealistic assumptions. For example, the ratio of test score to learning time as a comparative index of learning efficiency assumes a linear relationship between score and time.

Robert Dear[6] at System Development Corporation has developed a bivariate covariance model which tests the effect of independent variables on the joint vector of score and time. This model has been used in a study by Gunn[7]. Folletti[8] developed an index which incorporates both accuracy of performance and cost factors such as training and test time.

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[4]Hammock, Joseph. Criterion Measures: Instruction vs. Selection Research. Murray Hill, New Jersey: Bell Telephone Laboratories, September 1960. 8 p. (Offset)

[5]Gilpin, John. Design and Evaluation of Instructional Systems. Paper Presented in a Symposium at the 1961 Meetings of the American Psychological Association. (U. S. Office of Education Grant No. 7-12-026.00) Richmond, Indiana: Earlham College, 1961. 8 p. (Mimeo.)

[6]Dear, Robert E. Multivariate Analyses of Variance and Covariance for Simulation Studies Involving Normal Time Series. FN-5644, System Development Corporation, 28 November 1961. 60 p.

[7]Gunn, Evelyn. An Analyses of Reading Comprehension and Programing Methods Using a Bivariate Covariance Design. FN-6298, System Development Corporation.

[8]Folletti, Joseph F. Effects of Training Response Mode, Test Form, and Measure on Acquisition of Semi-Ordered Factual Materials. Research Memorandum 24. Fort Benning, Georgia: U. S. Army Infantry Human Research Unit, April 1961. 62 p. (Mimeo.)

In summary, it is proposed that a high payoff would be obtained if as much effort were devoted to the dependent variable as is now spent on the independent variable in programing research. The nature of the criterion variable determines the outcome of the experiment no less than the treatment conditions themselves.

INSTRUCTIONAL TELEVISION AND MPATI

presented by

Leon Hibbs

Midwest Program Airborne Television Instruction

MPATI is a regional experiment with four educational objectives: to offer courses which schools -- particularly smaller schools -- are not able to offer because of lack of equipment, facilities, or instructional competence; to improve quality of instruction in subjects which are offered in most schools -- large as well as small; to achieve the first two at a lower cost than possible by some other means; to donduct the project so it can be continued if Midwest educational leaders feel that airborne instructional television is a worthwhile educational investment.

In addition to the educational objectives, there are two technical aims:

-- To test the practicality of regularly transmitting a reliable and effective television signal from a high-flying aircraft.
-- To determine if it is possible to double the number of television channels by telecasting on a three megacycle band rather than the standard six megacycle channel. The narrow-band experiment will be conducted in June, 1962, after the educational experiment is completed.

MPATI is striving to achieve these objectives by having carefully selected teachers prepare taped lessons, then telecasting these lessons from two UHF transmitters located in a DC-6 aircraft orbiting 23,000 feet over Montpelier, Indiana. The telecasts are transmitted over an area 400 miles in diameter, covering parts of six states. There are approximately seven million students within the range of the airborne transmitters.

Lessons are offered at elementary, secondary, and college levels, five hours a day, a total of ten program hours per day -- over two channels -- Monday through Thursday of each week.

A full academic year of telecasting began on September 11, 1961, and will conclude after 32 weeks on May 24, 1962. Last spring, sample lessons were broadcast to give schools an opportunity to preview some of the course material. During the summer MPATI telecast utilization materials to 42 workshops attended by approximately 7,000 classroom teachers and school administrators. Also during the summer, test signals were transmitted to assist installers in testing and adjusting school receiving systems.

The cost of the project covering the period from the fall of 1959 through May, 1962, is approximately $8,500,000. Approximately $7.2 million is from the Ford Foundation; the remainder from other foundations and industry. Most of the funds are being used to meet the cost of operating the aircraft and transmitting equipment and the production of the courses of instruction. Together, these two functions account for over 80% of the cost of the project.

There is no cost to schools this year, other than the expense of installing receivers or converting their VHF equipment so that it will also receive UHF signals. In addition, schools pay $2 per copy for a classroom teachers' guide which is available for each course.

MPATI operates within the corporate framework of the Purdue Research Foundation which provides needed legal and fiscal services. The Midwest Council, comprised of 15 prominent educators and civic leaders from the six-state region and headed by Dr. Samuel Brownell, Superintendent of the Detroit City Schools, performs a policy-making role similar to that of the Board of Directors of a large corporation. Administration and operation are in the hands of a small professional staff located here at Purdue.

The telecast region is divided into 20 "resource areas" each with an area committee composed of educators and civic and business leaders who have joined together to assist with the project. Twenty leading universities -- one in each area -- have offered to cooperate with MPATI and make their resources available in the fields of teacher training, research, and evaluation. A faculty member at each resource institution serves as the MPATI coordinator for the respective area. The area coordinator works with and through the area committees to provide two-way communication between the schools and communities on the one hand and MPATI on the other.

Three major segments or branches within MPATI make up the airborne instructional television system.

The first is concerned with development of instructional materials. This includes selecting courses, selecting teachers, planning the courses, recording the lessons on video tape, and finally reviewing and approving the taped materials.

The second includes all the technical operations. This involves the design, installation, testing and operation of the airborne transmitters; the provision of hangars, maintenance facilities, and a tape duplicating and storage center. Also included are provisions for giving technical advice and assistance to schools concerning receiving equipment.

The third is responsibility in providing assistance to the utilizing schools. In actuality, MPATI has no responsibility for what goes on in the classrooms where the televised materials are being used. Each school may use the materials in such fashion as the teachers and administrators feel appropriate.

Course offerings have been developed by taking advantage of the advice of leaders in education from the Midwest region.

In keeping with this policy, the Midwest Council, with the help from the six-state superintendents in the region, appointed a Curriculum Policy and Planning Committee and Subject-Matter panels in each of seven subject-matter areas. These panels helped us design our materials to fit in with curriculum practices in each of the six states.

Within the framework of the recommended curriculum, three series of offerings were planned for the experimental period. The first series includes two offerings in elementary science, 6th grade arithmetic, French and Spanish for the elementary school, and two courses in elementary school music. At the senior high school level, there are courses in American history and world history. The algebra and chemistry for college and advanced high school were produced by Learning Resources Institute for Continental Classroom.

Second series' materials were added to Series One materials for telecasting the present five-hour-per-day schedule. This series includes English language arts for 3rd and 4th grades, mathematics for gifted children, junior high, science and Russian for college and advanced high school. The biology course has been produced by Learning Resources Institute for College of the Air. Third series' courses are now in production. Selected materials for this series will be scheduled for broadcasting beginning in January, 1962, including primary science, 3rd and 4th grade social studies, junior high Spanish, and American literature.

At the same time the curriculum for MPATI was being selected, an intensive teacher-talent search was conducted to find outstanding television teachers. Potential teachers were identified from cities throughout the U.S. Audition kinescopes, transcripts, publications and resumes were obtained from 356 teachers. These materials were reviewed and evaluated by the TV Teacher Preliminary Screening Panel. The membership of this panel included experts in education and educational television. The Council used the recommendations of this group to select the MPATI teaching staff. The teachers have produced their lessons at 10 separate production centers.

In order to provide the teachers with necessary help and feedback, production teams were organized. Generally, these teams have six members: teacher, educational associate, course consultant, program associate, subject-matter associate, and producer-director.

The final stage in lesson production is the acceptance of a video tape, meeting prescribed academic and technical standards. The next job is to put the lesson on the television screens in the classrooms.

A great deal happens, however, between the time when a taped lesson is accepted and the time it is put on the air.

First, a duplicate tape is made. Two tapes are needed for telecasting purposes; one for the aircraft scheduled to fly, and the other for the standby aircraft. The duplicates are made in the Purdue Tape Processing Center, adjacent to the MPATI offices. The Center is equipped with five Ampex video tape recorders.

When the duplicate tape of the lesson has been completed and checked for quality, the duplicate and master are put in the Tape Library. By the end of next May, the library will contain more than 2,000 lessons.

Two days' tapes are loaded on each aircraft because weather conditions may occasionally require our aircraft to spend the night at another airport. We want them to be able to carry out the following day's assignment without first returning to Purdue to pick up tape.

Our aircraft are four-engine Doublas DC-6A's, equipped as flying television stations by the Westinghouse Electric Corporation.

The DC-6A is the cargo version of the DC-6 and is admirably suited to MPATI purposes because of its operating altitude, lift capability, and reliability, and the ready availability of parts and heavy maintenance service.

Each aircraft is equipped to telecast programs simultaneously on UHF channels 72 and 76. Each program originates in the aircraft in a video-tape recorder which feeds a 5-kilowatt transmitter. The output of the two transmitters are then fed to a single antenna which has a power gain sufficient to give us an effective radiated power of 50 kilowatts on each channel. This is roughly the same as the Columbia Broadcasting System station serving New York City from the top of the Empire State Building.

In order to cover a service area extending out to the radio horizon, some 200 miles away, the antenna which extends 25 feet below the aircraft while in flight, was designed to radiate a disc-like radiation pattern, with maximum energy radiated toward the horizon. The antenna is kept vertical at all times by a gyroscopically controlled hydraulic and electrical system.

To provide power for the transmitters and auxiliary equipment, some 90 kilowatts are needed. This requirement is met by a generator driven by a gas turbine, mounted in the tail of the aircraft.

Programs originate in the aircraft in video-tape recorders. This method of program origination was chosen for the initial project, but it is not the only possible method. If more than two programs are to be telecast simultaneously and MPATI is thinking in terms of four or more simultaneous programs in the future, it is probably better to originate the programs on the ground and relay them to the aircraft by means of a microwave link. Receivers in the aircraft would pick up the relayed programs and feed them to the airborne telecasting transmitters.

For telecasting, the aircraft flies in a narrow figure-eight pattern, the axis of which varies with the wind direction. A special navigation system provides the pilot with a display which shows him his position with respect to Montpelier. He also has at his elbow a weather radar which enables him to avoid thunderstorms and other regions of air turbulence. Two-way radio keeps the plane in constant communication with the Purdue airport.

Satisfactory reception of MPATI transmissions requires a well-built UHF antenna with a suitable directional pattern, properly located with respect

to the surrounding terrain and structures. It may require a UHF amplifier to overcome line losses between the antenna and the rest of the system. It requires a converter to change the UHF signals to VHF signals if VHF receivers are to be used. The MPATI signal itself is being steadily improved. At the beginning of scheduled telecasting in September, picture quality did not measure up to the standards we have set. As a result of intensive engineering efforts, transmission quality has been substantially raised. These efforts are continuing and will continue until MPATI signal quality matches the best in current practice.

Consumers are the teachers and students viewing and using the telecasts in about 2,000 equipped schools with one or more TV sets to receive MPATI. These schools enroll over 1,000,000 students.

There is a wide range of ways in which Midwest educators can make use of MPATI's resources. The twenty colleges and universities which serve as resource institutions are one source of assistance, working through the area committees and area coordinators. Other resource organizations are the MPATI demonstration schools which have been equipped with receiving systems donated by TV equipment manufacturers.

There are three major kinds of professional services MPATI provides Midwest schools and colleges. The first of these is direct service to schools -- to teachers and administrators -- such as lesson guides. A second group of services includes use by faculties of teacher education. College students can view regular in-school telecasts as part of their college work in education. Prospective elementary teachers can view lessons in music or language arts to get ideas for teaching in these subject areas.

In coming months, MPATI will explore with Midwest educators other ways that MPATI can be of service; planning with demonstration schools and other equipped schools so that student teachers from the colleges can work under the supervision of classroom teachers in equipped classrooms gaining first-hand experience in using television in teaching.

Another important long-range possible service of MPATI is to cooperate with schools of education in the planning, production, and telecasting of series of professional offerings, such as a series in the psychology of learning or on the teaching of reading.

A third kind of service lies in the field of educational research and evaluation. MPATI is assisting participating schools with their own local evaluations.

In addition, MPATI is cooperating with Midwest research agencies in conducting a number of region-wide studies. Examples of these region-wide studies are two studies being planned by the Ohio State University Bureau of Educational Research and Services. One of these studies, for instance, will examine the role of the classroom teacher in utilizing MPATI.

Also, MPATI is engaging in a number of developmental studies aimed at improving the quality of its offerings. An example is a "teacher response" card that allows teachers to evaluate the quality of reception, the studio teachers' methods, the lesson material, and the uses of visuals and demonstrations.

In reviewing the three segments of MPATI it can be said the technical system is operating satisfactorily. In respect to development of course materials, steady progress is being made in improving quality.

The area in which the greatest increase in emphasis will occur in the future is in cooperating with schools and colleges to aid their programs for improving classroom utilization of televised materials.

In assessing the contributions which MPATI can make, it is hoped that educators will base their judgements on the potentialities of the technical system to bring materials to the classroom in an effective fashion, rather than basing judgements on a particular course or lesson. If the airborne transmission facility operates reliably, efficiently, and economically, its potentiality as a servant of Midwest education is demonstrated.

MPATI has had many inquiries regarding the future of the airborne system. Will it be continued in the Midwest? What about establishing additional MPATI's in other areas? What are the potentialities of the system for use in foreign countries?

In the Midwest, MPATI is working with educators and lay citizens in planning a permanent organization to continue as a non-profit educational corporation with schools as members. A board of directors, elected by the member schools, would be responsible for major policies.

In this region, the system can be put to other uses, such as adult education or agricultural extension service. Equipped schools could be used in late afternoon or evening as viewing centers for the telecasts. Additionally, more and more home sets will be adapted for UHF reception. There is interest in other sections of the country in the MPATI system. If other regional projects are created, course materials can be exchanged, allowing quality to be increased at lower cost.

Possibly the most challenging potential use of the airborne system is in the less developed countries of Africa, South America, and Southeast Asia. It could be used for in-class instruction, and also for education of whole communities. The illiteracy barrier could be hurdled, since it is not necessary for people to be able to read to be taught sanitation, improved farming methods, and certain skills. A great advantage of using an airborne system in foreign countries is the ease with which it can be installed. All that is needed to install is an airfield from which the flying television stations

can operate. Another advantage lies in the fact that it can be operated and maintained by a small staff located at one place - the airfield.

The three uses of the airborne system mentioned here -- its continued use in the Midwest and expansion of its use to other localities in the U. S. and to foreign countries -- give some idea of the range and flexibility of the system which is being used operationally for the first time in history in the Midwest as a resource for the classroom teacher.

EDUCATIONAL DATA PROCESSING

Murray Tondow

Chicago Teachers College - North

I should like to delimit my remarks this afternoon from the rather wide scope of the given title "Educational Data Processing" to those aspects of data processing that relate primarily to the learning process as differentiated from the structure and form of education. I believe this will be more in harmony with the other papers of this panel. A discussion of data processing limited to the learning process can be construed as more difficult than one concerned with structure and form because less has been done in this area - or it can be seen as easier to speak of because one's imagination is less likely to be inhibited by experience and its usually sordid details of trial and tribulation.

Before I start the main body of this paper I would like to make some comments concerning structure and form in education. When one separates this aspect from the learning process it is like our separation of mind and body - convenient but not real. Anything done in education must effect the learning process. For example, about a year or so ago, I was involved in a project concerned with automating attendance procedures for a large school system. This system, when in full operation, would result in a savings of approximately 36,000 teacher hours a month. Obviously such time available to the school system would in all probability have to do with the learning process itself even though the project had responsibilities toward areas of the school ecology other than the pupil-teacher relationship.

In the time remaining I would like to address myself to five points. While time alloted me requires a brief discussion of these points, I feel a compulsion to at least spread them before you for your reactions:

1. The basic role of EDP in the technological configuration in education;

2. An example of this role;

3. The first step necessary for successful conceptualization and operation of EDP in education;

4. The particular effect that EDP has and will have upon the mechanics of teaching;

5. What I consider the most important implication - and challenge of EDP for education.

It seems to me as we continue to utilize more and more technological segments in education, perhaps the most important role of EDP will be that of integrating and coordinating these different techniques and tools. It alone has these capacities, to store, and retrieve information, and blend the use of the various technologies, thus optimizing the value of technology to education. The whole is more than the sum of the parts - indeed impact potential is more geometric than arithmetic with a constantly changing synergy as one adds technological components.

An example of how the computer integrates and coordinates is our usage and planned usage of technology at Chicago Teachers College - North. We are a new institution having opened just this past fall. We are an experimental college with a mandate to predict the world of education in the 70's and to educate our students for this anticipated work environment. I shall briefly - very briefly - list the components of our system and show how all are tied together by the computer:

1. A rear projection audio-visual installation with two large (14' x 11') screens. One screen can handle the images from two (2" x 2") random access slide projectors. The other screen presents material projected from a slide projector or TV projector or a 16MM motion picture camera. Thus a total of three images can be projected simultaneously on both screens. The rear vie projection permits the room to be lighted at all times during usage and also permits work on the equipment without disrupting the auditorium. The lectern has a TelePrompter as well as a control panel for control and use of the audio-visual equipment. The equipment can be handled from the lectern by the professor or can be programmed with punched cards. This first phase has been installed and debugged and does into operation January 2.

2. We are at the bid stage for a 10 channel conduit connecting all classrooms and other teaching facilities. It is our hope that 10 channels will permit us to utilize at least some of the electronic devices anticipated over the next several years.

3. We are at the design stage for individual student response units. They will be portable in order to afford maximum use. There are five buttons on each unit and we use the binary number system so that we have all the possible response potential we think we shall need - namely 31 possibilities. We hope to be using about 100 of these units by this summer.

4. Located in our hallways are some 216 individual study carrels or cubicles. By summer some 30 of these carrels should have audio-visual components permitting the student to check out programmed learning material from the library for use in the carrels. In addition the portable response units previously mentioned can also be used at these stations. The carrels will also be used in conjunction with TV presentation.

5. We expect during this calender year to install sufficient TV facilities to permit us to utilize programs from our local

educational channel and from MPATI and also to experiment with closed circuit TV.

6. All these facilities will be tied to, and coordinated, by our computer. The computer along with other EDP equipment will be the logic center - the heart, soul and brain of the system. It will permit the widest use of stored data for teaching as well as an ongoing analysis of the learning process.

A brief description such as this does not permit full elaboration, but before moving on I should like to say that not all our explorations into teaching and learning are limited to electronics.

As described above we are approaching technological usage on a modular basis. That is, we view each entity as a sub-system capable of being used separately as well as part of a larger system. Perhaps the most important value of such a procedure relates to a question very often raised in discussion groups such as ours here this afternoon, namely, "What's the first step for getting started with EDP in education?" Usually the discussion centers around such things as money, need, system analysis and readiness. While these are important they are all highly personal to each situation. It seems to me that the first generalized phase common to any use of EDP in any educational situation relates to the integrity of the system (both man and machine aspects). While I have never heard this point discussed, my experience leads me to feel that the development of integrity is necessary though not sufficient for a system to succeed. What I mean here is that the doers must feel absolutely assured that their system can work so that they may proceed during the periods of necessary change and difficulty that are inevitable in system development. In addition, the user must view the system as having integrity - this does not necessarily imply efficiency but rather the consumer must accept the system as operating on a series of principles and that any errors or discomforts that may occur are not aimed at the individual or group. Once the consumer accepts the system as having integrity then, and only then, is it possible for the system to change and modify without misunderstanding and opposition, both overt and covert by the user.

Perhaps an example at this point would help to clarify the above. We recently installed a central secretarial service. All a faculty member need do day or night - is lift the phone in his office, dial 8, and start dictating. The words are recorded on disks and later typed. Initial faculty reaction was not that the system was inefficient but rather that it does not work because it is unfair - that some people get preferential treatment. This was not true. On the secretarial side, personnel did not know what their authority and responsibility was.

An iron clad rule was established: first come, first serve; absolutely no priorities except by written memo from the Dean of the college.

The secretaries were told they would be fired if they did not adhere to this procedure. Immediately both doer and user tested the limits. Within a week feedback changed from anti-system to acceptance of system, but rejection of the workability of the rule (the very one that had been asked for!) What was being asked for now was not elimination of the system but rather improvement of the system. The system now was in a position to modify and change without any reflection upon its ultimate value. In short the integrity of both worker and equipment had been established. This example has been greatly over simplified but I hope it gives some clarification to the concept of system integrity. Before leaving this example a quick three part aside:

1. Given a clear role and a sense of correctness of the machine components, the efficiency and morale of the typist increased significantly.

2. In the four months of operation no faculty member has ever gone to the Dean of the college concerning priority needs.

3. No faculty member has seen fit to recommend a priority procedure for the work handled by the secretarial service.

By developing our electronic learning system on a modular basis from the known (audio-visual) to the less familiar, we hope to develop an acceptance of the system and its integrity so that each addition will not require a complete program of re-education on the part of our consumers - namely faculty and student.

Two obvious results of EDP in education, insofar as the mechanics of teaching is concerned, is the use of stimulation as a teaching procedure, and the use of individual study since the computer permits the keeping, analyzing, and rapid retrieval of large amounts of data concerning each student. The continual up dating of academic data permits programs, at least at the college level, of a much more individualized nature.

With all of the face changing that EDP is doing in education the most fundamental implication is the new role of the teacher. The teacher is no longer the best channel for the storage and dissemination of information - computers are much more efficient. In a world changing and adding new facts as readily as ours, the relative inefficiency of using teachers to disseminate information becomes more obvious daily. Science is changing the teachers' role from that of a technican to that of an artist - the teacher must do things that machines cannot do and must also give meaning to what machines can do. The teacher must help the student integrate individual facts - must give meaning to the facts - must motivate the student to learn and use what has been learned. Thus, teaching becomes ever more an art because these new emphases are essentially handled through interpersonal relationship, which at the present state of the art is primarily an art. It is true that the

good teacher does these things now, but the change is that in the future this will not be an ancillary or implied function but the primary function of the teacher. In addition the teacher will no longer be measured by how much the student knows as is most generally the case now, but rather on these additional attributes of the student just mentioned.

In closing I should like to make three comments. Each of these points were implied in the body of this paper, but I should like to end by making them explicit:

1. Technology does not have all the answers and our approach to its use is at this time essentially pragmatic.

2. Rather than dehumanize the education process, technology offers the first real hope of individualizing our system of universal education.

3. And finally, let us not lose sight of the fact that we have just begun to be confused. We are just now scratching the surface of what appears to be an important positive contribution to education and therefore, to all of mankind. But as of now we are not sure of our direction and the ultimate impact remains unknown, so that what technology requires above all else from the educator is courage:

   a) The courage to try,
   b) The courage to fail,
   c) And above all else the courage to succeed.

AUTOMATION AND EDUCATION

Launor F. Carter

System Development Corporation

FORWARD

Because the System Development Corporation has a serious interest in the application of automation techniques to institutions, we have been doing research in automated education for around two and a half years. During most of this time the members of SDC's Automated Education Research Staff have been John Coulson, Harry Silberman, John Cogswell, Ralph Melaragno, Don Englund, Don Bushnell, Don Estavan, Maury Silber, Don Marsh and Evelyn Gunn; in recent months Dave Ryans, Robert Egbert and Jerry Newmark have joined the efforts to increase our involvement in information processing and training applications to educational systems. Much of the material I am reporting here, primarily that dealing with SDC's education research program, represents the hard work of this group rather than my own personal work. While I have attempted to give continuous broad guidance to the overall project, most of the credit belongs to those named above.

Introduction

It is my aim in the paper to discuss the general aspects of how automation techniques can be introduced into the educational system. I believe that at the System Development Corporation we are developing a broad system approach to this problem of introducing technology into education and part of this paper is devoted to describing our program. First, however, I would like to discuss the popular conception of education--the popular conception held by so many members of the public--and also to consider some of the ways in which automated equipment can be of real assistance throughout the total school system.

The Image of the School

To see what this challenge is let us look first at the popular idea of the educational system. Our image of "the school" is usually a large, square room with about 40 pupils seated at rows of desks; some books are open and a teacher is lecturing. This popular picture is probably the same today as it was two or three hundred years ago. Since the time of Socrates there have certainly been the teacher and pupils; for the last three or four hundred years there have been books. These three ingredients--the pupils, the teacher, and books--have constituted the important parts of all educational systems.

Is it not surprising that today's picture of the education process is so similar to the picture that was held hundreds of years ago? There are few other areas in modern life where this is still true. The great impact of technology has been felt in almost all other fields. Farming, transportation and homemaking, the basic occupations of mankind over the centuries, are all viewed today in terms of a highly complex technology--in terms of tractors and mechanized farm equipment; in terms of airplanes, trains, and cars; in terms of electric stoves, refrigerators, vacuum cleaners, and frozen food. Most of this change has come about within the last hundred years and great changes are still taking place with dramatic rapidity. Yet in education the impact of technology has had only a nominal effect.

Some time ago, a Sunday comic strip pictured education in the classroom of tomorrow. It showed many ingredients of the technological change which will be discussed in this paper. In the picture the pupil is seen at an individual console which will allow him to receive instruction over television or allow him to have individual instructional material presented by a teaching machine. He can be asked questions and respond to them and immediately be shown how well he did. There are motivational devices such as lights and bells. In the picture there is even a shapely and graceful...is it mother or teacher or friend?

This may, indeed, be the way in which much of our education will be presented 20 years from now. But what forces are going to bring this about? What are today's developments which may make this science-fiction comic strip the classroom of tomorrow?

In thinking about these questions I asked myself, "What are the goals of education?" "What are we trying to achieve?" In giving my answers, my frame of reference will be the child from the age of 5 or 6 up to 16 or 17; thus I am going to consider the situation in what we commonly refer to as the public schools (although I think these concepts--particularly the system of analysis I am going to illustrate--can be applied equally well to training in industry or in the military). I suggest that we attempt to understand the impact of automation on education by engaging in armchair analysis of the educational situation as it concerns children in this age group. A really thorough system analysis would demand a great deal of careful data collection, study, and analysis. By contrast, what is presented are personal, rather carefully thought out but idiosyncratic ideas about the educational system.

The Goals of an Educational System

Initially we should ask, "What are the goals of a modern system of education?" Table I lists some of the goals. Most people think these are important in the development of the child as he progresses toward adulthood; many would agree that these goals to a large extent fall outside of the immediate, primary responsibility shouldered by the parents.

TABLE I

PARTIAL LIST OF EDUCATIONAL SYSTEM GOALS

1. Imparting subject matter
2. Training in thinking and creativity
3. Developing skills and techniques
4. Developing attitudes
5. Socializing
6. Physical development
7. "Child care"

The first goal shown in Table I is to impart subject matter. Most of us forget how much content matter the young child must learn and how rapidly the bulk of it is increasing. So we have a great need to increase the efficiency with which pure content is transmitted to the learner.

The second goal of the educational system is to develop within the individual an ability to reason and to think, to be creative in attacking life's problems. Some will say that the schools are not giving adequate training in this area, and yet a great deal of school time is actually devoted to this subject. When we compare the naive first-grader with the high-school senior, it is apparent that the school or some like experiences must have trained the individual or developed in him certain capacities to reason and think.

The third goal of any educational system is to develop skills and techniques. For example, the student must be taught to write, to manipulate equipment, drive a car, and so on. Particularly among those who will enter the skilled or semi-skilled occupations, the development of skills such as welding or metal-working or the development of the agricultural skills is of tremendous importance.

The educational system also has a great responsibility for developing desirable attitudes. Of course, other sectors of the child's environment (the home for example) also have a responsibility in this area. It is in the educational system, however, that much of the common and uniform attitude development takes place.

Another goal, particularly for younger children, is the development of a certain degree of socialization. Training children to live in reasonable peace with other children and later, in teenage, meeting the need for a certain amount of heterosexual experience is an important aim of child development.

Still another goal is physical training. As our culture continues its trend toward urbanization, physical development and training away from the home become more and more important.

Finally, the child-care function is a goal of many educational systems. In many cases it is desirable to get the child out of the home for extended periods of time. This helps to develop socialization and to give broadening experiences. In many families, it frees the mother to work and to take part in activities which need to be carried out away from the home. In this way the school serves a very real purpose in our general scheme of urban life.

Some will disagree with this analysis of the particular goals of the educational system. They will want to change the emphasis, delete some goals, or add others. This is not critical to the general argument which leads us next to consider various implications of the goals with regard to the context through which they can be achieved.

In another paper (5) I have discussed the educational environment which is required to achieve these goals in the educational system. In that paper I state: "We can conclude that a well-rounded education which attempts to achieve the goals listed requires that adults be involved--that is, teachers participating in the educational process. Second, it is probably necessary to have this process take place in a special setting--that is, separate from the home. We can also conclude that other children must be involved, that the learner cannot

by himself achieve all of the goals listed. Finally, we can conclude that books are required but do not play the dominant role usually supposed and that teaching machines will probably play an equally restricted role."

Technology in the Educational System

Having concluded that we need school systems in much the same setting as we now know them, it is interesting to look more closely at the way in which various new techniques might be applied in the educational system to assist in some of the functions which are essential to achieving the goals we have discussed. Table II shows educational-system functions broken into a number of the detailed activities necessary to achieve the goals we have considered.

TABLE II

EDUCATIONAL-SYSTEM ACTIVITIES AND TECHNOLOGY

System Activity	Punch-Card Equipment	Computers	Teaching Machines	Special Aids
Instruction				
1. Classroom Instruction	NO	YES	YES	YES
2. Homeroom Period	NO	YES	YES	YES
3. Laboratory Work	NO	YES	YES	YES
4. Physical Training	NO	YES	YES	YES
5. Driver Education	NO	YES	YES	YES
6. Library Work	YES	YES	YES	YES
Guidance				
7. Student Guidance	YES	YES	NO	NO
8. Testing for Guidance and Content	YES	YES	YES	YES
9. Registration	YES	YES	NO	NO
10. Room Assignment and Scheduling	YES	YES	NO	NO
Administration				
11. Cumulative Record-Keeping	YES	YES	NO	NO
12. Report-Card Preparation	YES	YES	NO	NO
13. School Personnel Records	YES	YES	NO	NO
14. Fiscal Records and Control	YES	YES	NO	NO
15. School Logistics	YES	YES	NO	NO
16. Administrative Planning	YES	YES	NO	NO

Grouped together at the top of the Table are activities dealing with instruction (the transmission of information, attitudes, etc.); in the middle of the Table are the functions connected with guidance; administrative activities are at the bottom of the Table. How can these activities be served by simple punch-card equipment, by digital computers, by teaching machines, and by other special aids?

Let us look at the column headed "Punch-Card Equipment." Interestingly, punch-card equipment does not seem to contribute at all to the immediate goal of transmitting information to the students or in helping to achieve the more traditional educational goals. However, when we come down to the necessary but less training-oriented activities such as registration, room assignment, etc., we see that punch-card equipment can make a contribution; it certainly can be used in the whole area of personnel records, property records, control of school logistics, and so on.

Turning to the column headed "Computers," it is surprising to see all "YES's"; the computer could be used in all these activities. It clearly could be used in those places where it is indicated that punch-card equipment could be used, but it could also be used in classroom instruction, laboratory work, and the like if we recognize that a computer could be an integral part of a teaching-machine installation in a school.

The next column asks whether or not teaching machines could be useful in all these school activities. (It is assumed here that we are talking about teaching machines which are not computer-based. If we were talking about a computer-based teaching machine, we would combine the two columns, "Teaching Machines" and "Computers.") The "Teaching Machines" column indicates that the teaching machine can be used for all of the instructional activities, including physical training. A certain amount of physical training is the transmission of information about the body and its control, about posture, etc.; this information can be given on a teaching machine, as can certain aspects of the strategy and tactics of field games. Going beyond the instructional and library areas, a "YES" has been noted for the use of teaching machines in testing for guidance and content. Obviously, a teaching machine can indicate very satisfactorily the progress a student is making; it can also be of great assistance in guidance. In registration, assignment, record-keeping, etc., the teaching machine does not seem particularly useful.

The fourth column, "Special Aids," includes all the many audiovisual and training aids which can be produced by our advanced technology. Television, films, devices for driver education, and microfilm readers for the library (to mention only a few) can be very useful in the educational system and can perform certain functions better than teaching machines.

Table II seems to indicate that it would be useful--perhaps extremely useful--if computer-based teaching machines and computers themselves were introduced into the educational system. They would help fulfill an important function in the many different activities listed. The question is often raised whether or not school systems can possibly afford large general-purpose computers. Maybe they cannot now, but with the new developments in computer technology just over the horizon, we would be foolish not to start thinking and experimenting now. I for one am convinced that, in the long run, economics never stands in the way of technology.

SDC's Research in Automated Education

SDC's research work, particularly our first teaching machine, represents some of the most advanced techniques used in this area; therefore, it is worthwhile to describe this machine and the kind of instructional technique which it makes possible.

One of the major differences between the SDC teaching machines and others is the great flexibility that is achieved by using a small, digital computer as the control mechanism for the teaching machine. The total machine is shown in Figure 1 and consists of:

1. A computer which controls the presentation of instructional material to the student.

2. A large random-access slide projector which presents the instructional material and projects it.

3. The screen on which the student reads the material and the typewriter on which the student responds.

A control tape containing all the instructions is loaded on the computer; it tells the computer what to do for each student response. The tape also tells the computer in what order to present items, when to skip items, when to present remedial material, what kind of feedback messages to give the student, and how to record the student's progress.

The random-access slide projector stores up to 600 items of information. The computer can command the projector to show the slides in any order appropriate to the progress of a particular student. The student reads the item as it is projected on the screen and responds to one of the alternatives. He types his response on an electric typewriter which communicates with the computer.

The computer program determines whether or not the response is correct and whether new material should be presented. The computer also causes the typewriter to type out an appropriate feedback message. In addition, the computer keeps a record of the student's response; thus, at the end of a particular exercise, the instructor can secure a summary score or printed report of the student's response to each individual item.

In preparing items for a particular subject, the designer must plan how many items are going to be given for each phase or small part of the subject matter. He must decide how rapidly the very good student can probably go through the material and design a program for him. Then he must design a program for a less able student and perhaps still a third for a fairly poor student. In other words, flexibility must be introduced into instructional programs so that the good student will be motivated and not have to respond to repetitive material; the program must also be designed so that the poor student will remain motivated but not get items which are above his level of ability. SDC currently has instructional material for such subjects as history, symbolic logic, geometry, and computer programming.

Figure 1. SDC's First Teaching Machine

The First experimental computer-based teaching machine used by the Automated Education Project at SDC for research in auto-instruction. On the left is the Bendix G-15 Computer and on the right, the teaching machine unit which houses a random-access slide projector, rear-view projection screen, and an alpha-numeric typewriter tied to the computer.

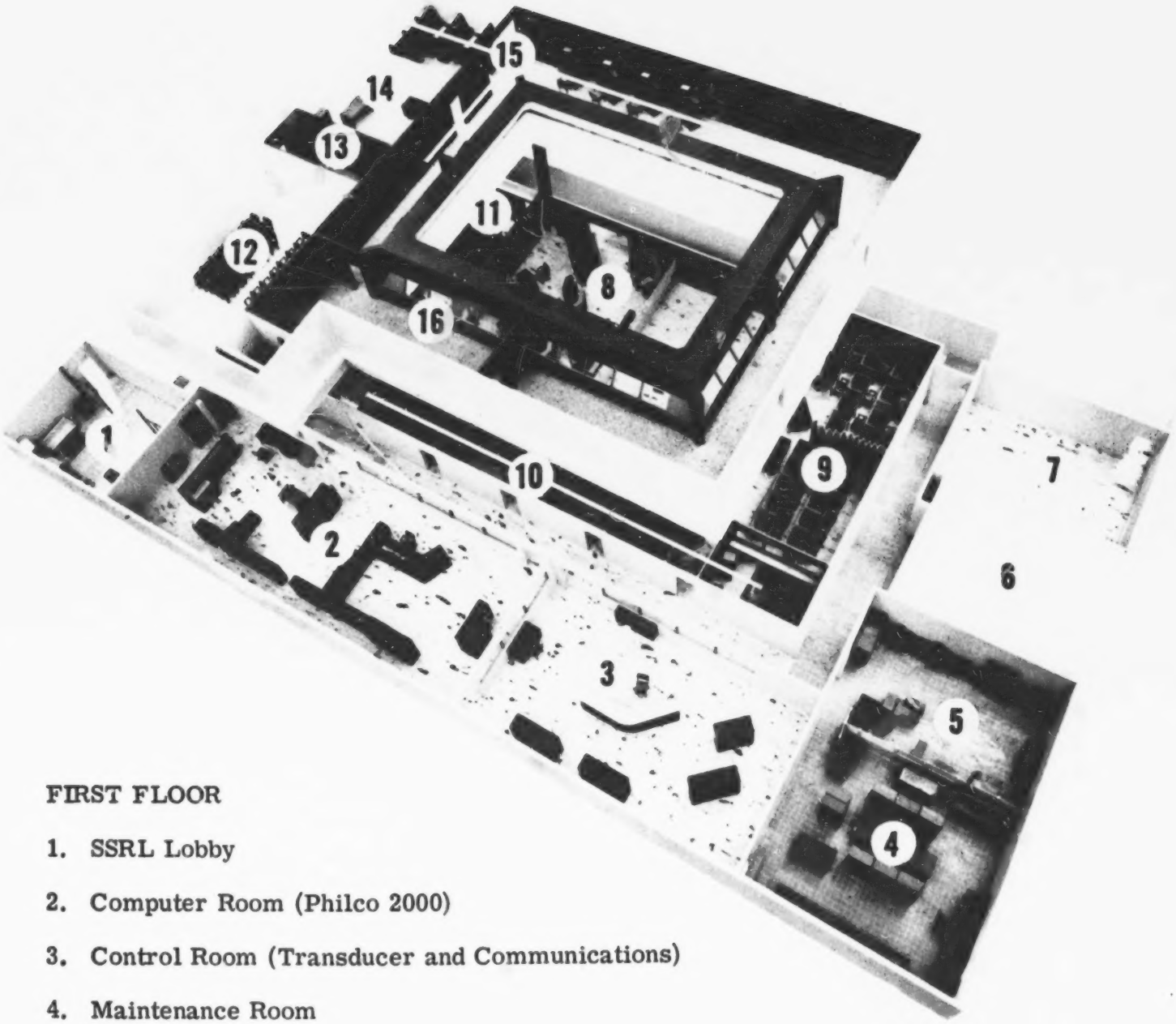
Provided with a well-designed teaching program, SDC's teaching machine gives information to the student, tests his knowledge of the information as he progresses, gives the student immediate knowledge of results, continually modifies the detail and complexity of the information presented as a function of the student's actual performance, and allows the student to make certain decisions himself depending on how satisfactorily his progress has been.

It becomes evident that the most important problem in the teaching-machine area is not the design of the machine itself but rather the design of good instructional material. Most of the research now going on has to do with problems in making instructional items. Among the questions under investiation is the relative value of very small, easy steps between items in contrast to fairly large, difficult steps. Another problem is whether or not the question or test-type item should be asked frequently or infrequently. Also of concern is whether the student can passively receive material or must make an active response to it. There is likewise concern with the efficiency of using feedback loops and the introduction of remedial material for the poorer student. Still another area of interest is the problem of motivation and the possibility that the proper planning of instructional material will better motivate students at all levels to learn and retain the material presented to them. Further, it is believed that the teaching machine may well have different effects for overachievers and underachievers.

While the advantages of flexibility in instructional programs are indicated by our knowledge of individual differences and motivation, it is only recently that there has been clear experimental evidence on the point. Coulson and Silberman (14, 16) have conducted experiments showing that automated instruction which flexibly adapts the student's sequence of instructional material to the individual student is superior to the same material when not adapted to the individual student. In their latest study, two groups of matched students were given identical items in symbolic logic. One group of students was given a fixed sequence of items covering the material. The other group of students had the same material available, but the instruction to the individual student was modified on the computer control as a function of the student's progress. The results show that the group trained by the flexible, adaptive sequence took less time to learn and scored higher on a criterion test than did the fixed-sequence group.

The Systems Simulation Research Laboratory

The System Development Corporation and The RAND Corporation have for years had various simulation laboratories. Because of SDC's extensive research work in this area we have felt the need for a laboratory with a large digital computer as its basic control mechanism. In September 1961 we completed the construction and installation of a new laboratory called the Systems Simulation Research Laboratory (See Figure 2). This unique laboratory contains our CLASS facility, i.e., the Computer-Based Laboratory for Automated School Systems.



FIRST FLOOR

1. SSRL Lobby
2. Computer Room (Philco 2000)
3. Control Room (Transducer and Communications)
4. Maintenance Room
5. EAM Equipment Room (Data Preparation)
6. Air-Conditioning Equipment
7. Offices and Ready Room
8. Main Experimental Area
9. Experimental Area (Used for CLASS)
10. Small Experimental Rooms
11. Observation and Debriefing Area

SECOND FLOOR

12. Briefing Room
13. Projection Room
14. Aids Preparation Room
15. Experimenters Observation and Simulation Area
16. Visitors Observation Area

Figure 2. Replica of Systems Simulation Research Laboratory

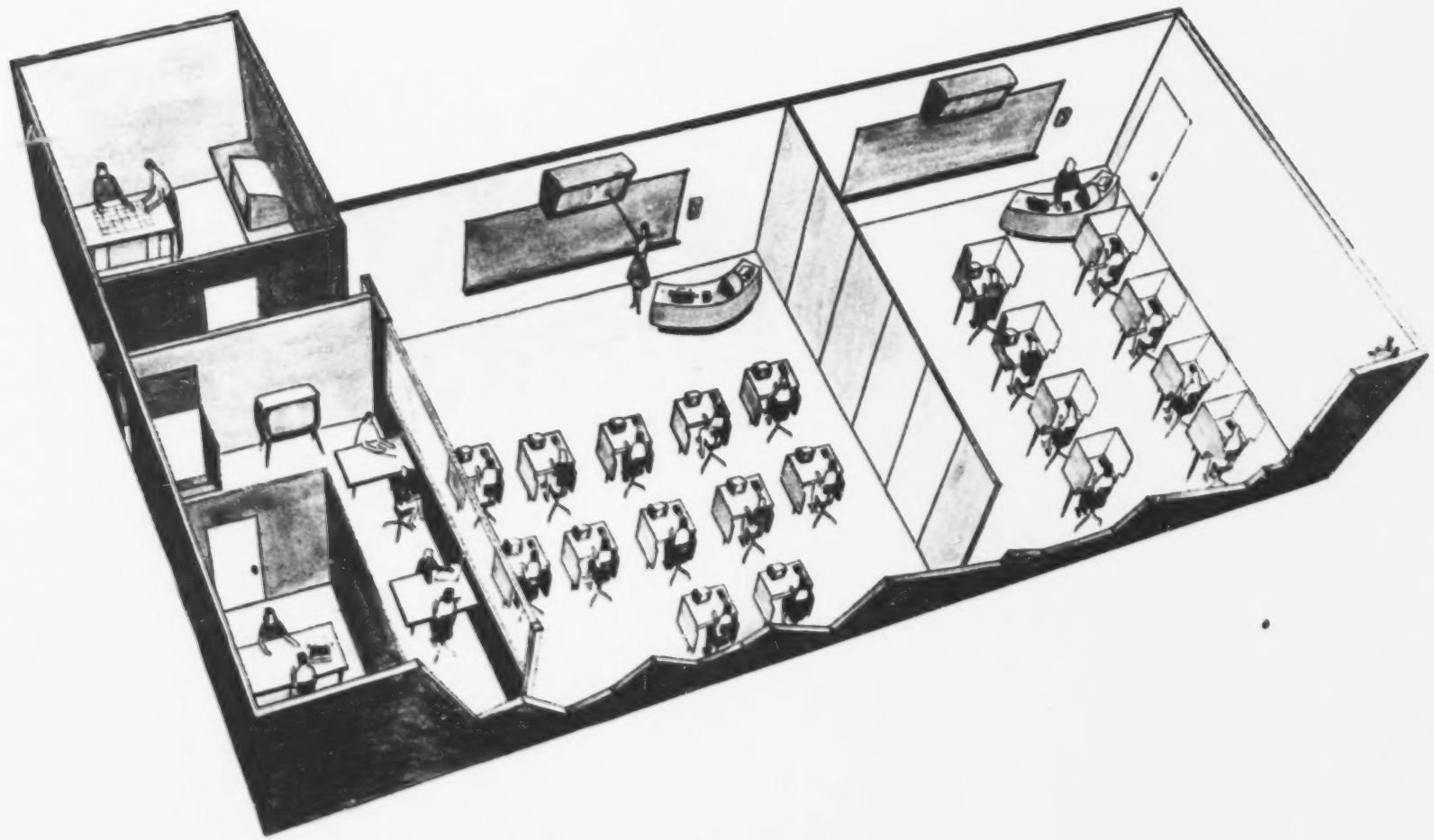


Figure 3. The CLASS Facility

The illustration shows, moving from left to right, the administrative area, hall, combined observation and counseling area, and the large automated classroom divided by a sound-attenuating folding wall.

The CLASS Facility (See Figure 3)

The CLASS facility is composed of four general areas. First, there is the large classroom area. In this area 20 students can be exercised and trained at one time, or it can be divided to teach 10 students in each of two separate areas, with different modes of instruction.

Adjacent to the classroom is the second major area--the counseling room. Here students can be called in for individual counseling or teachers can discuss the student progress or student problems with the counselor. The third area is a small office for the school principal--the administrative area, where we hope to study problems of school administration. A fourth room not shown in Figure 3 is the central audiovisual display area. This room contains the camera for the closed-circuit television and the various display mechanisms which the camera photographs. There is a 16 mm movie film projector, a random-access slide projector and a film-strip projector. The presentation of material from this remote display room is through television repeaters in the classroom. The display materials are remotely controlled by the teacher in the classroom.

There are three different ways in which we are using this facility at the present time: an individual mode, a group mode, and as a foreign language instruction laboratory. Each of these will be described in detail.

The Individual Mode

Figure 4 shows a student being instructed in the individual mode. The large box is a film viewer which will hold up to 2000 frames of 35 mm film. The student selects the frame based on instruction from the smaller box called the response device. This device enables the student to select the answer to a particular question by pressing one of five keys which communicate with the computer. On the top of the response device are some lights which flash back to the student an indication of the correctness or incorrectness of his response. In addition, there are lights beside each of the keys which can be used as a further reinforcing mechanism. The device also incorporates a digital display on which up to four items of digital information can be displayed to the student. For instance, it can give the frame number of the display that should be used next, or perhaps print out a cumulative total of the number of correct answers given. The three buttons on the left are used to select the particular subject matter in which the student should be trained. At the present time, the computer is set up with a logic lesson, a short history lesson, and a French lesson. The student can select the subject matter to be taken by pressing the appropriate button. Throughout a lesson, each student responds at his own individual rate, which means that he is getting instruction according to the particular progress that he as an individual is making.

Figure 5 shows the teacher at his desk and the equipment on the desk. From right to left, there is the digital display monitor, which is a cathode ray

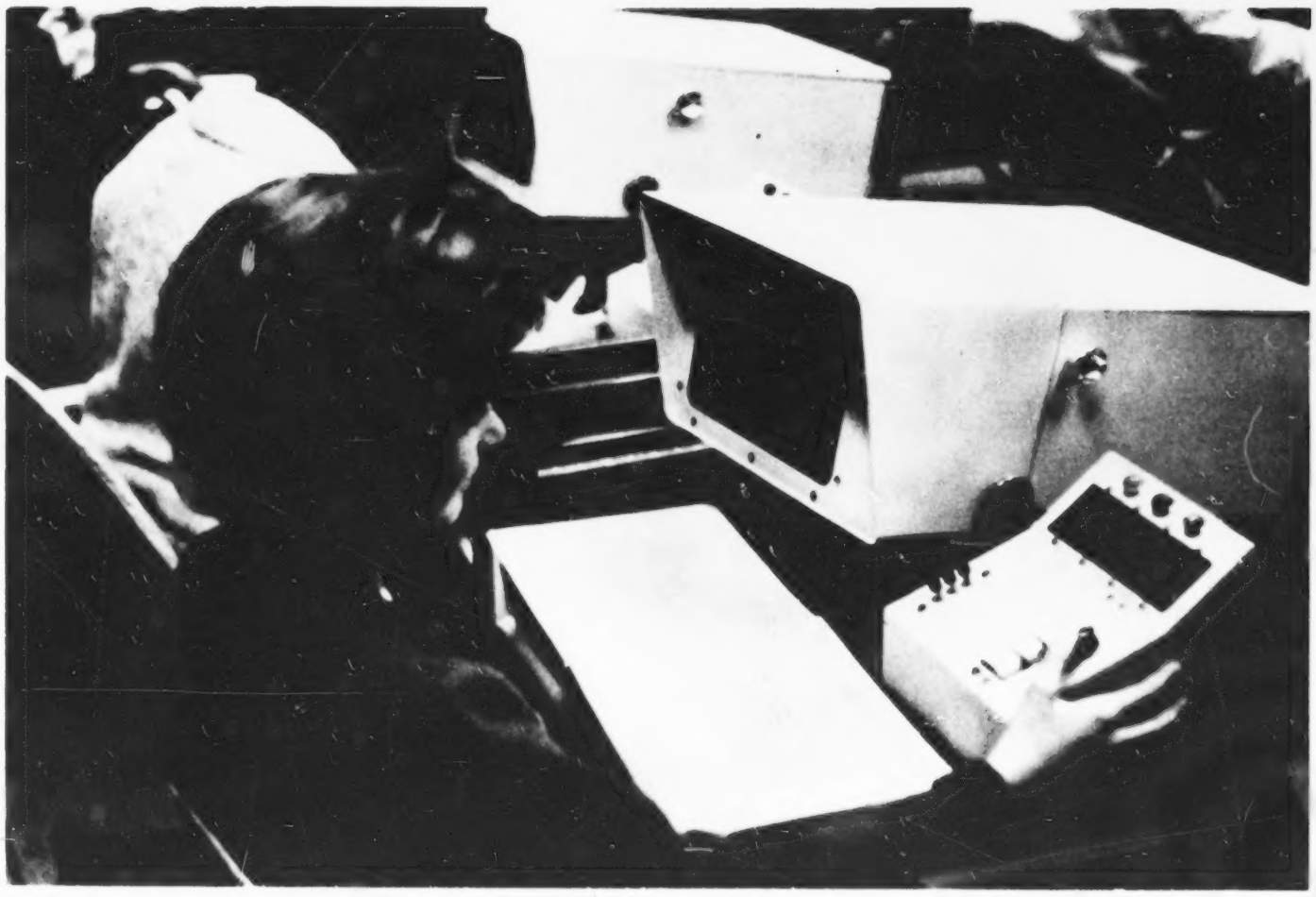


Figure 4. Instruction in the Individual Mode

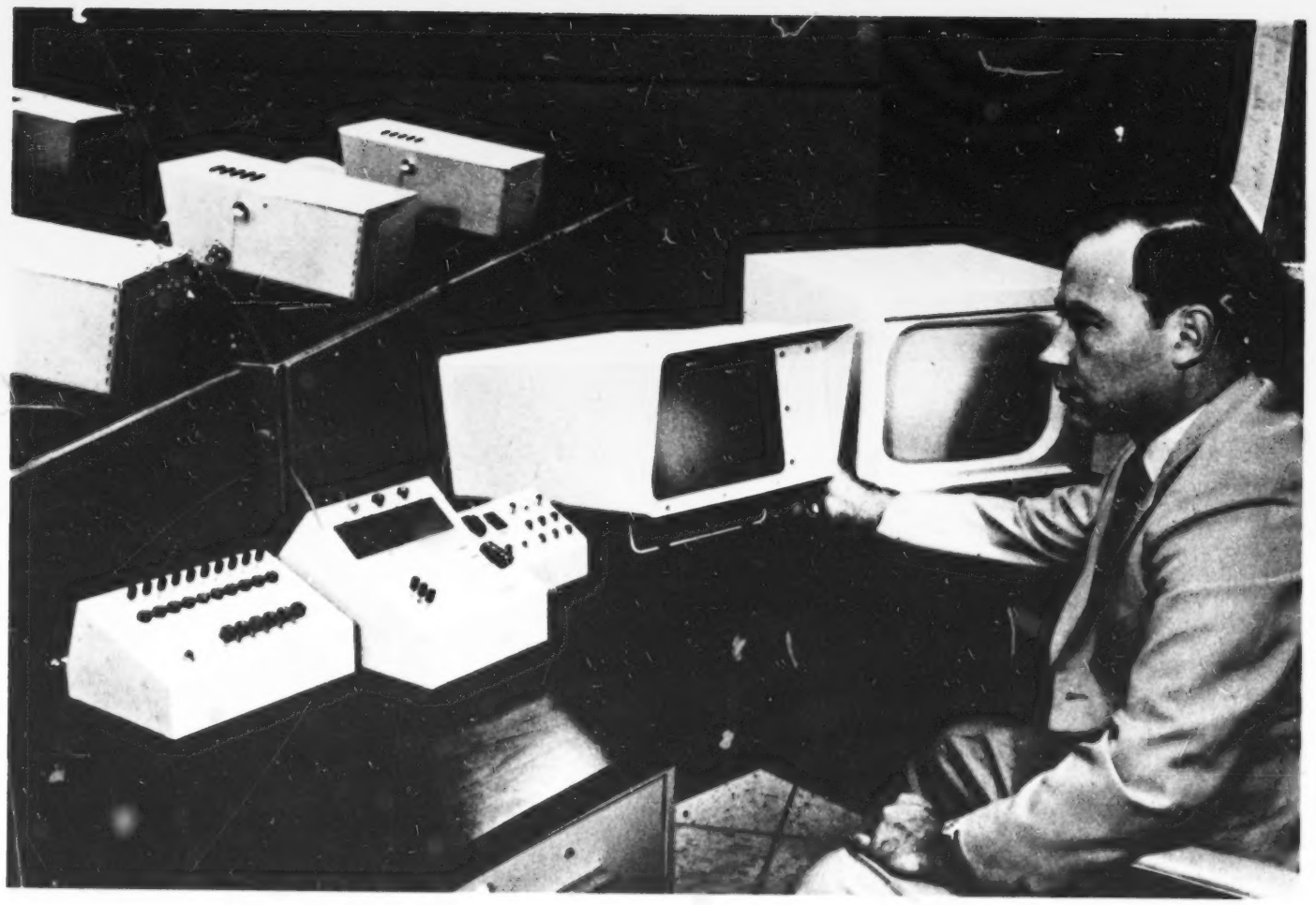


Figure 5. The Teacher's Desk

tube used to display printed material from the computer. Next to it is a film viewer on which the teacher can request the same lesson material that the students are working on. If a student is having difficulty, the teacher can view the material before going to help the student individually. The small box to the left of the film viewer is for remotely controlling the various audiovisual components. Next is the response device which is the same as the students have on their desks. The teacher may, if he wishes, set this in series with any student response device so that he can see how the student is responding. On the far left is the teacher console which enables him to monitor the responses for each individual student. The teacher can request information from the computer on each student by pressing the button corresponding to that student. Also, a red light will light up if a particular student is progressing slowly or missing a lot of items and is in need of help. By monitoring the student's progress, the computer can indicate to the teacher which student should have individual assistance.

All of this equipment would be used by the teacher and students if instruction is being given in the individual mode. In this mode, each student can be studying a different subject matter; moreover, he will be going through it at a rate and in a fashion unique to his particular learning requirements. The student is essentially being tutored individually. All of the student responses are being permanently recorded by the Philco S-2000 computer which is in real-time operation with the CLASS facility. CLASS has space to accommodate only 20 students; however, the computer is "idling" with this few students. We have calculated that the Philco S-2000 could easily handle up to 300 students in the individual mode or up to 800 in a group mode.

The Group Mode

The group mode is similar to the individual mode and can use the same equipment or additional equipment (See Figure 6). The classroom contains two television repeaters so that material from the central audiovisual area can be seen by all the students. In this mode all students see a common display or can hear a discussion by the teacher or can engage in any other type of common education activity. Throughout the presentation of the material, testing items can be interspersed to which each student responds on his response device, so that a continuous running record of the student's understanding of the material can be kept for later analysis by the teacher or for immediate diagnostic work if the teacher feels that some student is falling behind.

We have also fitted the laboratory for instruction in foreign languages. We have not gone as far here as we intend to, but at the moment we can use either the television display or have the teacher hold up display cards with which various vocal stimuli are associated. A tape recording amplified through a loudspeaker system can be synchronized with the television display so that the material is pronounced in the foreign language concurrent with the visual display. The current teaching of foreign languages at the elementary level

Figure 6. Instruction in the Group Mode

tends to be based largely on the thesis that superior achievement can be made if all the instruction is given using the foreign language supported by visual display material which the student understands. While being shown displays, the student can respond through his response device to questions asked in the foreign language regarding items displayed. Later we intend to modify the laboratory for foreign language instruction so that each student can get an individual verbal presentation through headphones and through a tape which he can control himself. Thus we believe that we can achieve all the flexibility of individual tutoring even in the foreign language area.

The CLASS Facility as Used for Counseling

We are just now developing the techniques for using CLASS for counseling students. Using CLASS for this purpose involves the storage of all the student personnel records on magnetic tape. If these records include the aptitude test scores, the family biographical material, the student's past record, as well as the current record of progress, the counselor will have at his disposal information on which he can do good counseling. It is our feeling that we can assemble this material, store it, and display it in a much more usable form than is currently the practice. Moreover, this information, including student progress, can be made immediately available. Through the computer the counselor will be able to call up the progress of any student at any given time; but more than that we can so program the computer that it continually monitors the progress of each student and alerts the counselor as students fall below some set criterion. At the present time counselors often have to wait until a teacher refers a student to them and a teacher may or may not be sensitive to the problem a student is having. With the CLASS facility this could be done automatically and the counselor could take a much more active role in keeping students from getting into serious educational problems.

Administrative Use

A digital computer available to the central office of any large school system would be of great use in the many activities associated with administration. So far we have not developed programs in this area but are planning to do so. A system such as our CLASS facility with its computer could be useful in many administrative areas. For instance, it could support the planning activity that takes place in any large school system. Recently we have been talking to one of the large metropolitan schools regarding their problems in planning classroom use and the construction of classroom facilities. This is an extremely complex problem involving population shifts, availability of teachers of different subject specialties, real estate values, and many other variables. All of this could be programmed and optimized. Another major problem in school systems is scheduling. The scheduling of classroom assignments, the finding of conflicts in student schedules, the scheduling of teachers to various classes, and the myriad different detailed schedule problems which all have to dovetail to have a smoothly running system could easily be handled by a computer.

Another major area is report preparation. School administrators have to prepare a large number of reports to their county superintendents, or to the State Department of Education, or elsewhere; and of course the traditional report cards need to be prepared. These can be handled efficiently through a computer installation. Another use is in the area of logistics. As school systems become extremely large, the problem of accounting for books, for equipment, for facilities of all types becomes quite cumbersome and could again be handled by a computer system, as many logistics systems are nowadays handled. Of course, the same can be said for the various aspects of fiscal accounting.

Another use of computers in the administrative area, particularly in a facility such as CLASS, is in the training of school administrators. Here we believe we can simulate the various problems that a school administrator might be faced with. We can devise various personnel problems, teacher problems, pupil problems, parent problems, community relations problems--and all these on top of the routine administrative duties. By appropriate simulation we can train school administrators to handle these problems, which offers considerable promise for improving educational administration.

Software Aspects of CLASS

So far I have been mainly describing the hardware aspects of the CLASS facility. Implied in all of this, however, is an area that is becoming known as the software area of automation. This is the area of the computer programs and the learning materials for learning programs which must be carefully constructed. So far in CLASS we have two hours' worth of a well-tried-out logic program. We have about 10 hours of high-school-level plane geometry and about 10 hours of digital computer programming instruction. We also have minor amounts of material for instruction in French and in history.

One of our major goals in the next few months will be to increase the amount of instructional material available in the facility. Our experience has indicated that one of the most difficult problems in the whole automated teaching area is the writing of good instructional material. We find that experts need to write the material and that it needs to be tried out and revised several times before it is really trouble-free.

Another major area of software in a computer-based system is the development of appropriate computer programs. We have now completed three major programs and are working on others. I should emphasize that the development of a computer programming system is a major undertaking. The Philco S-2000 computer is being programmed in the SDC JOVIAL language and a compiler has been developed for it which is in general use throughout the Research Directorate. In addition to the compiler we have three specific programs: a lesson assembler, a program called Mentor, and a data analysis program. I will describe each of these in some detail.

The lesson assembler program has been described by Englund and Estavan as follows:

> "The lesson assembler prepares the input tape describing the instructional lesson to the teaching control program, Mentor. Punched cards prepared from three different manuscript forms are its primary input.
>
> The first form, the counter manuscript, describes each of the counters to be used in the lesson. Counters are used for recording student errors within various parts of the lesson and for making branching decisions. The counter manuscript contains the following information for each counter:
>
> 1. The counter name;
>
> 2. A critical value or critical error count;
>
> 3. A transfer point indicating the remedial sequence to which the student should be branched if his error count reaches the critical value.
>
> As many as 32 counters may be used for each student in any lesson. The second form, the item manuscript, lists all items and describes their characteristics (i.e., page or frame number, number of responses, correct answer, maximum response time, and associated counters). One entry is required for each instructional item of the lesson.
>
> The third form, the flow manuscript, orders the presentation of items and specifies the logical and arithmetic statements which constitute flow decisions. The page numbers of the items are listed in the order in which they are presented. Each item can have additional flow dependent information supplied for it (i.e., feedback options, response-associated branch points, and additional concept associations). Statements written in an English-like language may be interspersed in the item list. These statements serve to change concept error tallies, set parameter values, and test arithmetic combinations of error and time tallies.
>
> An instructional lesson is assembled in a single pass through the lesson deck. All flow and item description information is assembled and placed in tabular form with all symbolic references to items, counters, and decisions made absolute. Each of the logical and algebraic statements specifying the flow decisions is compiled into absolute Philco 2000 machine language instructions."

The description of this program will give some feeling for the detailed complexity with which one must define the actions that have to take place in a computer-based automated teaching situation.

The second major program, called Mentor, is used during the actual teaching session. Besides controlling the sequencing of materials in the instruction program, it does a number of other things. For instance, it updates the student history tapes as each student responds. It decides on which item to present next to the student based on the lesson flow diagram and on the response which the student makes to each item. It also scores each item as the student responds, as well as recording the latency between the time the items was presented and the time of response. In addition, it feeds back information to the student through the response device. If desired it can also light the student alarm lights on the teacher's console.

The third program is a data analysis program. This is a fairly common program and simply describes each response made by the student. Depending on the teacher's preference, it can have material printed out by student, by instructional items, or by instructional concept. Likewise, there are various statistical summaries which can be made of the progress of the class, by various units such as by the hour of instruction or educational unit of instruction.

All of the above programs have already been completed and are in use. In addition, we are currently improving the teacher display and the teacher callup programs, which do not have the flexibility we would like to have in them. Another program that we are working on is a more complete student history tape. The present tape is fairly complete as far as instruction goes, but does not include all of the information needed for counseling. We would like to be able to store on the student history tape a diagnostic interview and be able to have it printed out for the counselor. Since the efficiency of an automated system depends upon the skill and appropriateness with which branching is done--that is, the way in which the lesson is presented to each individual student--we feel it very important to sophisticate the branching aspects of our instructional program and we hope to be able to develop a program which will take into consideration not only the individual's responses over a short period of time but will be able to evaluate these in terms of the student's general level of ability and his past performance on similar types of materials.

Future Work

With regard to future use of the CLASS facility, we feel our approach should be of a general development nature rather than a purely scientific one. We have a number of ideas regarding how CLASS should be used which we have implemented in our programming and construction of the facility, recognizing that these ideas are based upon our past research with a rather limited teaching machine. We need to try out the present facility in a quasi-operational environment to see how it will work best. We intend to test it with real teachers and students and will probably modify it considerably. The dynamic changing of a system of this nature is essential to a really good operational system. Therefore, one of the first efforts we hope to initiate next spring is the instruction of a real class of students, for which arrangements are now being made.

Concurrent with the testing and modification of the CLASS facility, we intend to use it for several research studies. We have two studies in mind at the present moment. One of these, currently in the planning stage, will be a study of the effects of delay in feedback on the progress of learning. In the psychological literature there is considerable evidence to show that there is a rapid falloff in the amount of retention or the amount learned as delay time between the response and feedback regarding the correctness of response is increased. It has been suggested that a delay of as much as ten seconds will cause a two-thirds reduction in the amount of material learned. On the other hand, there is some evidence from using teaching materials that the feedback does not need to be this fast. Therefore, we are starting a study in which there are two major variables: the length of delay and the nature of the material being learned. It is our feeling that where the material being learned contains a cue as to the correctness of the response and where this cue is present at the time of the feedback, there may not be any essential reduction in the amount of reinforcement of learning over rather long delay periods.

The second series of studies we intend to undertake involve a replication of some of the studies by Coulson and Silberman on the effects of branching. As I indicated earlier, we were able to demonstrate that branching improved the amount and quality of learning. However, the amount of improvement was not as large as we think it might be and we believe that one of the reasons was that our subjects were relatively mature, working on fairly difficult material. It is our belief that with young primary school children working on more elementary material the efficiency of branching will be much greater than so far demonstrated. Therefore, we will repeat some of the earlier work but with young children and fairly easy material.

It can be seen from all of this that there are many problems yet to be solved in the large-scale application of computer-based teaching in any practical situation. No doubt automated teaching not based on such a sophisticated system will be practical and useful, but I believe that in the long run and over many different subject matters and teaching conditions, the introduction of automated techniques into the public school system is inevitable. This introduction of automation will involve not only the teaching function, but all other aspects of the operation of the total school system.

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